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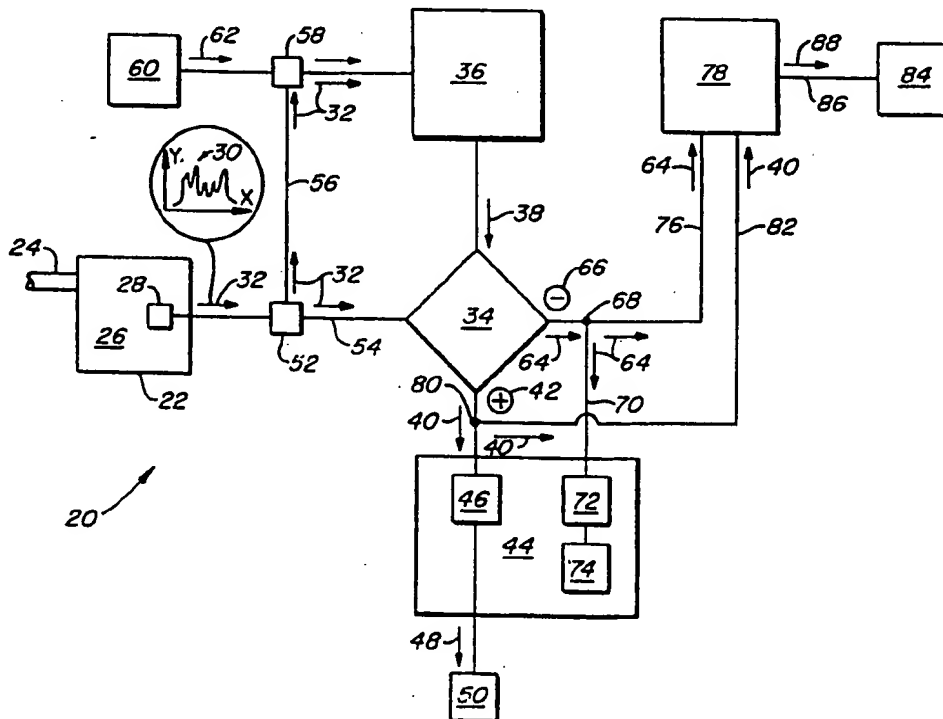
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(54) Title: SYSTEM FOR BREATH SIGNATURE CHARACTERIZATION

(57) Abstract

Apparatus (20) and method for generating a breath signature signal (32) for a person who delivers a breath sample to a breath sampler (22). A transducer (28) is communicated with the breath sampler (22), for sensing at least the temperature, the pressure and humidity of the breath sample. In response, the transducer (28) generates a breath signature signal (32) which distinguishes one person from another. The breath sample can be tested (a) for validity, (b) for distinguishing it on the basis of sex and age, (c) for selecting whether or not the same person delivered two different breath samples, and (d) for recognizing the identity of a particular person giving two different breath samples. Additional features include breath references (36, 36A-D, 38, 38A-D, 62), comparators (34, 34A-D), a distinguisher (34B), a selector, (34C), and a recognition means (34D).



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1 SYSTEM FOR BREATH SIGNATURE CHARACTERIZATION

5 TECHNICAL FIELD

 The field of this Invention relates generally to systems, both
apparatus and method, for characterizing breath samples of
humans. More specifically, this Invention relates to systems
employing a person's breath sample to develop a breath signature
10 signal; this signal can then be used to (a) identify characteristics
of the person and (b) detect the presence of drugs in the breath
sample, particularly alcohol.

BACKGROUND ART

15 Although various schemes have been devised for analyzing
human breath samples in order to obtain information about a per-
son, particularly information relating to the person's percent blood
alcohol concentration (BAC), there continues to be shortcomings
and deficiencies in the technology. Specifically, existing breath
20 analysis techniques simply do not provide approaches for gathering
information other than BAC about the person from a breath sample.
Examples of existing technology are discussed below.

 U.S. Patent 4,093,945 to Collier et al discloses a breath test-
ing system for alcohol intoxication breath testing. The system in-
25 cludes (a) a breath input unit, (b) a controller which delivers a
sample of deep lung breath to (c) an evaluator including an alcohol
detector and an output apparatus. The controller includes a
breath flow sensing means to insure that a deep lung breath
sample is tested. A passing signal cannot be obtained unless (a)

1 the predetermined continuous and uninterrupted flow has occurred,
and (b) the resulting sample tests below a predetermined alcohol
concentration.

U.S. Patent 4,316,380 discloses a system for determining the
5 alcohol content of the breath of a test person. The system (a)
measures the alcohol content of the breath to produce an alcohol
content signal, (b) measures the change in the alcohol content sig-
nal, (c) measures a flow of the breath of the test person, and (d)
10 indicates the alcohol content using the alcohol content signal only
when the change in the signal per unit time is below a pre-selected
change value and the flow is above a pre-selected flow value, and
further where the flow has not dropped below the predetermined
flow value since it first reached the predetermined flow value.

U.S. Patent 4,317,453 to Heim et al discloses a system for
15 testing a person's breath for the determination of its alcohol con-
tent. The system first determines when the breathing air is at a
condition in which breath testing results will be effected. This is
done by arranging a capacitor in a breathing tube through which
the breathing air is directed.

20 First the capacitor is heated to a predetermined temperature,
and then the breathing air is directed over it so as to cool the
capacitor until it has attained a predetermined temperature change.
This temperature change is such that it will take place when a
person's breathing air has its desired consistency.

25 When this occurs, the breathing air is then directed into a
test chamber, in which it is tested to determine the constituency of
the breathing air, particularly the percentage of alcohol which it
contains. A device for testing a person's breath, in addition to the
tube through which the breath is directed containing the thermal
30 capacitor, also contains a test chamber which is connected to the
tube with control means, which senses the temperature of the
capacitor and permits the flow of the gas into the test chamber only
after a predetermined temperature drop has taken place.

U.S. Patent Application having Serial Number 06/494,301, filed
35 May 13, 1983, by Brian P. Elfman and Lawrence T. Rojahn, now
abandoned, discloses an apparatus for measuring the blood alcohol
concentration (BAC) of an individual. The apparatus includes a gas
vapor sensor for receiving and analyzing the alcohol concentration

1 vapor sensor for receiving and analyzing the alcohol concentration
in the breath of the individual, an analog-to-digital converter, and
a gas analyzer for detecting the rate of change of the signal gen-
erated by the sensor. When the signal rate of change is at or near
5 zero, thereby indicating the breath is deep lung air, the sensor
signal is transposed to a blood alcohol concentration reading in the
BAC look up table, and then compare to a pre-recorded level ob-
tained from a memory, to determine the intoxication level of the in-
dividual. A flow sensor can be provided to assure that the in-
10 dividual is expelling a sufficient volume of air to assure a good
reading. An auto ignition gate can be provided to disable a vehicle
if the individual is found to have a BAC reading above a predeter-
mined level which indicates intoxication.

15 While the above printed publications do offer laudable ap-
proaches and solutions with respect to the particular situation each
addresses, none of them individually or in a combination disclose or
suggest the invention defined in the appended claims of this present
case. Specifically, the following problems persist despite the efforts
of the existing technology.

20 All the above approaches are specifically directed to determin-
ing the BAC of a person in order to prevent that person from
operating a vehicle if he is inebriated. No additional information
can be determined by these systems from the breath sample. These
systems are not sophisticated enough to accurately and reliably
25 identify a particular person, or select a specific person out of a
group of persons, or specify a person's sex and age.

Existing breath analyzing equipment, to provide a breath
sample test result which can be introduced into evidence in a drunk
driving prosecution, must be built to very precise specifications,
30 are large and not easily transportable, and are sensitive and thus
require frequent servicing in order to remain precisely calibrated.
As a result, the available equipment is quite expensive. Because
the accurate equipment is not easily transportable, an arresting
police officer faces a race against time in getting an inebriated per-
35 son to the equipment's location quickly enough that a person's body
does not metabolize the alcohol prior to a BAC test. Additionally,
these systems have difficulty in accurately detecting attempts to
deliver bogus breath samples to them, for example in case where an

1 inebriated person #1 has a breath sample delivered by a sober person #2. The opportunity also exists to introduce a bogus breath sample originating in a compressed air bottle or having been filtered prior to being subjected to a BAC test.

5 These are only a few of the problems which have not been adequately resolved by the existing technology. Because of these problems, it became necessary to devise the Invention (1) disclosed by example below, and (2) defined in the appended Claims.

10

DISCLOSURE OF THE INVENTION

Solutions and advantages are offered by this Invention which resolve many of the deficiencies still existing in the current technology.

15 Broadly summarized, this Invention provides a system, both apparatus and method, for generating a breath signature signal for a person who delivers a breath sample to a breath sampler means. The apparatus comprises a transducer means, communicated with the breath sampler means, for sensing at least the temperature, the pressure and the humidity of the breath sample, and in response
20 generating a breath signature signal which distinguishes the person from a plurality of persons.

Additional features include apparatus and methods wherein:
(a) the breath sample is a deep lung breath sample; (b) the breath signature signal comprises a frequency spectrum generated by the
25 integration of at least the temperature, the pressure and the humidity of the breath sample; and (c) the integration is performed by the transducer.

Further included is a validifier means for determining that the breath sample is delivered unaltered to the breath sampler. The
30 validifier means first comprises a valid breath reference means, for representing the valid common range of values of at least the temperature, the pressure and the humidity of the typical breath samples taken from a reference population of persons. The
validifier means second comprises a comparator means, coupled to
35 the valid breath reference means and the transducer means, for comparing the breath signal against the valid breath reference means to determine if the breath sample is valid.

Still another provision provides for a distinguisher means for

1 distinguishing , with respect to the person, both of (a) a male from
a female, and (b) a child from an adult. The distinguisher means
first comprises a separate class reference means for each of at least
5 a group of four separate classes comprising respectively a plurality
of males, females, children and adults. The class reference means
contains at least the ranges of the temperatures, the pressures and
the humidity of the typical breath samples characteristic of each of
the classes. The distinguisher means second comprises the distin-
guisher means being coupled to the comparator means for comparing
10 the class reference means with the breath sample of the person, to
identify the person as being both (1) one of a male and a female,
and (2) one of a child and an adult.

Another option includes a selector means for determining if a
later breath sample was delivered by the same person who delivered
15 an earlier breath sample, the selector means being communicated
with the breath signature signal of both the earlier breath sample
and the later breath sample, for comparing the breath signatures to
see if they are the same, to thereby indicate that the same person
one of (a) did and (b) did not deliver both breath samples.

20 Also included is a recognition means for providing a positive
identification of a person delivering a breath sample in the future.

The recognition means first comprises a personal identification
reference means, created by recording a specific breath signature
signal produced by the transducer means in response to a specific
25 breath sample delivered in the present by each of a group of
specific persons who are to be identified in the future according to
the specific breath sample to be given in the future by each of the
specific persons.

The recognition means second comprises the comparator means
30 being communicated to the personal identification reference means
and the transducer means, for comparing each of the specific breath
signature samples to the values stored in the personal identification
reference means, to confirm one of (1) the same person delivered
both of the present and the future breath samples, and (2) the
35 same person did not deliver both of the present and the future
samples.

Another feature adds a sensing means, communicated to the
breath sampler means, for detecting the presence of a drug in the

1 breath sample, including a drug which is an alcohol.

 This Invention begins and takes off from the point where the existing technology ends, by greatly expanding the technology of breath sampling, to thereby permit the acquisition of new and more sophisticated information about the person giving the breath sample.

 A key feature and advantage of this Invention is that, on the basis of a single breath sample from a particular person, a breath signature signal can be generated which is unique for that particular person. Once this breath signature signal is stored in some form of memory device, future breath samples generating future breath signature signals can be compared against the stored signal.

 This is a very important technological breakthrough. This breath signature signal can be used in (a) establishing the validity of a breath sample, (b) distinguishing a person's sex and age on the basis of the sample, (c) selecting among a group of persons to see if two breath samples came from the person, and (d) recognizing the identity of the particular person delivering the breath sample.

 The plural apparatus and method of this Invention employs a simple, sophisticated and inexpensive transducer to measure the temperature, pressure and humidity of a breath sample. The transducer then integrates these values together to produce a single output breath signature signal in the form of a frequency spectrum unique to the person delivering the sample. The frequency spectrum is then stored and used as a reference template against future breath samples.

 The existing technology requires complex apparatus to measure temperature, pressure and/or temperature and pressure together; these values are then manipulated by complex mathematical formula to obtain information about the breath sample. Complex flow meters are used to insure delivery of a deep breath sample. The only value measured is the BAC, and that is measured with a chemical sensor. In contrast, this Invention performs a simple joint measurement of temperature, pressure and humidity combined, integrates this measurement, and produces as an output the breath signature signal.

 The apparatus of this Invention is rugged, accurate, reliable, easily calibrated and supplies breath sample information that can be

1 used by the prosecution in a drunk driving adjudication. When in-
stalled in a vehicle and interlocked into the vehicle's ignition sys-
tem, it would be impossible for an inebriated person to start the
vehicle.

5 Additional features and advantages offered by this Invention
are (1) described by example below, and (2) defined in the ap-
pended Claims.

BRIEF DESCRIPTION OF THE DRAWINGS

10 Figure 1 is a schematic diagram which shows the apparatus
and method of this Invention;

Table I, entitled "Determinations re Breath Samples", sum-
marizes the information this Invention can obtain from a breath
sample;

15 Figure 2 is a schematic drawing showing the voice creating
sub-systems of a human body;

Figure 3A and 3B illustrate two different breath signature
samples in the form of two different frequency spectrums in
response to breath samples and other human sounds created by the
20 Figure 1 schematic;

Figure 4 is a more detailed schematic of the apparatus and the
method of this Invention.

BEST MODE OF CARRYING OUT THE INVENTION

25 This Detailed Description, which incorporates the accompany-
ing Drawings briefly described below, offers specific examples (i.e.,
embodiments) of how to practice the Invention, but it does not ac-
tually define the Invention. Instead, the Invention is defined by
the numbered paragraphs of the appended Claims. This Detailed
30 Description sets forth the best modes presently contemplated by the
Inventor for making and using the claimed Invention. Further, this
Detailed Description is intended for facilitate, through example, the
understanding of the Invention defined in the Claims.

Figure 1 illustrates an apparatus or system 20 for performing
35 breath signature characterization.

A breath sampler 22 has a mouthpiece (not shown) communi-
cated through a tube 24, for a person to deliver a breath sample
into a chamber 26 defined within sampler 22. A transducer means

1 such as transducer 28 is communicated with breath sampler 22, in
this case being mounted within chamber 26 in a conventional man-
ner. Transducer 28 senses at least the temperature, the pressure
and the humidity of the breath sample admitted into chamber 26. In
5 response, transducer 28 generates a breath signature signal 30, also
shown as the signal 32 arrow, which distinguishes the person giving
the breath sample from a plurality of persons.

Signal 30 can then be compared in a comparator 34 with infor-
mation stored in memory 36. If this information, in the form of a
10 memory signal 38, is substantially similar to signal 32, comparator 34
generates an output signal 40 which says "ok" or "yes"; this output
40 leaves through the terminal indicated with a plus sign (+)
enclosed in a circle, marked with a reference numeral as a positive
response 42. Signal 40 enters an interlock 44 to activate and enable
15 circuit 46, which generates a signal 48. This signal 48 passes into
an ignition system 50 to enable ignition system 50 to be operated.

Additional apparatus and methods by this invention further
enhance its usefulness; these details are described below.

Signal 32 out of transducer 28 can be routed through a switch
20 52, to be routed unchanged as the signals 32 traveling through a
line 54 into comparator 34, and a line 56. A switch 58 receives sig-
nal 56 and routes it unchanged into a recording device such as
memory 36. The purpose of this approach is to provide a reference
signal within memory 36 against which a future breath sample 32 en-
25 tering comparator 34 would be compared.

However, other methods can be used for loading memory 36
with signals 38 for use by comparator 34 in comparing signal 32
against signal 38. For example, an input device, such as keyboard
60, can be used to feed reference signals 62 through switch 58 into
30 memory 36. These signals 52 would emerge as signals 38 retrieved
comparator 34 for comparison against breath signature 32. In this
mode, switch 58 would be thrown to block signal 32 coming from line
56. However, in the mode described in the preceding paragraph,
switch 58 is thrown to block signal 62 and admit signal 32.

35 If comparator 34 finds that signals 32 and 38 do not match, it
generates a "not ok" or "no" signal; this is indicated schematically
as a negative output 66 displayed as a negative sign (-) enclosed in
a circle.

1 Signal 64 enters a junction 68, to emerge unchanged as indicated at the two additional arrows marked with reference numeral 64. One signal 64 feeds along a line 70 into a "not enable" block 72, which generates an end signal. This end signal is sent to a
5 stop device 74 to not permit ignition system 50 to be operated.

 The other signal 64 emerging from junction 68 travels along a line 76 unchanged into a storage device such as a memory 78 for recording. Likewise, the positive signal 40 passes unchanged a junction 80 to a line 82 into memory 78 for recording. Memory 78
10 provides a record of each test made so it can be later determined how many tests were conducted, What the results of the tests were, both in terms of the breath signature signal generated as well as whether there was a pass (as at reference numeral 42) or a fail (as at reference numeral 66), the time of day, the date and other
15 information as desired. At a future time, an output device 84, coupled through a line 86 to memory 78, can retrieve a plurality of results 88 from memory 78. These results 88 will also include measurements of the percent BAC.

 Table I shows the range of information this Invention can
20 determine from a breath sample. Table I, located after this Detailed Description and preceding the Claims, is hereby incorporated by reference into this patent application.

 The lowest level of information or robustness is in determining "validity" of a breath sample. The question is: has the breath
25 sample been tampered with in order to permit the person to pass the breath test? Such alteration could be accomplished, for example, by passing the breath sample through a filter containing a desiccant in order to remove a drug such as alcohol. Removal of the alcohol or other drug by a desiccant will alter the humidity of the breath
30 sample. This alteration will result in a breath signature signal which is not valid. Therefore, an ignition system could not be enabled.

 With reference to Figure 1, the "validity" test would be accomplished by using an input device such as keyboard 60 to load
35 reference values 62 into memory 36, these values 62 representing an average of the humidities, the temperatures and the pressures of breath samples from a reference population. The essence of this approach is to determine that the test breath sample signature sig-

1 or not valid. Another example of invalidity would be a blast of a
pressurized gas from a gas bottle, which gas would not exhibit the
same "breath signature signal" as would air expelled from a human
being. A human lung breath sample will have a temperature, pres-
5 sure and humidity which would be absent from a gas sample from a
pressurized gas bottle.

The next higher level of information is the ability to
"distinguish" both a person's sex and age from a breath sample.
To accomplish this, memory 36 must be loaded with at least four
10 separate tables representing the classes of breath samples from
males, females, children and adults. This information most likely is
loaded by way of keyboard 60, but it could also come from actually
testing members from each of these four classes with sampler 22,
which could be stored and averaged for each of the four classes.

15 Then, when breath signature signal 32 is generated by
transducer 28, comparator 34 will compare signal 32 against each of
the signals 38 for each of the four classes of males, females,
children and adults. From this comparison, it can be determined
what is the sex and age (i.e. child or adult) of the person deliver-
20 ing the breath sample.

"Select" is the next higher level of intelligence. The question
is: is the person who delivers a breath sample in the future the
same person who delivered a breath sample in the present? To ac-
complish this, memory 36 is loaded with a breath signature signal 32
25 produced by the particular person to be identified in the future.
Then, at the future time, this signal stored in memory 36 is
retrieved as signal 38 for comparison within comparator 34 with sig-
nature 32. This will give the result of saying that both breath
samples came from the same person; however, this breath sample
30 will not positively identify a particular person by name.

"Recognize" is the highest level of intelligence which can be
determined by this Invention. The purpose is to positively identify
the name of a person giving a future breath sample. To accomplish
this, the breath signature signal 32 of every person to be identified
35 in the future must be stored in memory 36. Therefore, in the
present each person must generate a breath sample in sampler 22
which is then stored as a breath signature signal 32 in memory 36.
At a future time, another breath sample is taken. Comparator 34

1 compares this new signal 32 against each breath signature signal stored in memory 36 until the identity of the specific person by name is produced.

5 Sounds such as voice and expelled breath produced by the human vocal system is a complex signal influenced by many facets of human physiology. As shown schematically in Figure 2, the human vocal sound system is influenced by a multiplicity of chambers and solid structures. Within a chest cavity 90 is at least one lung 92 powered by a diaphragm 94. To expel or exhale a breath sample, 10 diaphragm 94 pushes upward in a direction 96, causing the air within lung 92 to move upward into lower wind pipe 98 through voice box 100, through an upper windpipe portion 102 into an intermediate chamber 104 which is generally designated as the pharynx.

15 The breath sample continues through mouth tube 106 into a branch region 108. At this point, the breath sample is divided so that some of it proceeds up a nose tube 110 into a nose chamber 112 and out through a nose port 114. The other portion of the breath proceeds from branch region 108 into a mouth chamber 116, to be 20 expelled from a head 120 through a mouth port 118.

This human sound system 89, when expelling a breath sample through mouth port 118, generates a very complex sound. All of the just described chambers and structures of human sound system 89 has its own individual effect on this sound. The breath sample 25 sound includes effects and characteristics resulting from the temperature, the pressure and the humidity of the breath sample.

According to this Invention, it has been found that the breath sample of each individual has its own unique characteristic temperature, pressure and humidity which effects the frequency spectrum 30 of the range of frequencies of the sounds contained in the breath sample.

Figures 3A and 3B show two different curves 122 and 124, which are frequency spectrums typical of the kind that can be produced as a breath signature signal by this Invention, on the 35 basis of a breath sample from a person. Each person produces varying amplitudes (the Y-axis) of frequency values as the frequency increases along the X-Axis. beginning at zero and moving toward the right. Within this frequency range 126, defined

1 between the lower frequency F1 and the higher frequency F2, it has
been found that frequency spectrums representing by 122 and 124
are identifiable to particular persons. That is, a person A produc-
ing a frequency spectrum 122 shown in Figure 3A would differ from
5 the frequency spectrum 124 made by a person B as shown in Figure
3B.

By digitally sampling each of the curves 122, 124, etcetera for
different persons, a voice print can be developed and stored in the
form of a template in a computer memory. Then, a second spectrum
10 developed as a breath signature signal can be compared to a stored
template to see if they substantially overlap. If they do, then the
breath sample "passes". If they do not, the breath sample "falls".

This Invention, using the transducer described further below,
measures the values of a breath sample's temperature, pressure and
15 humidity, and integrates these values to produce a resultant single
breath signature signal 32, which is stored as a template developed
from digitally sampling the frequency spectrums 122, 124 etcetera
developed as in Figure 3A and 3B. Either the frequency spectrum
or the template developed from digitally sampling the frequency
20 spectrum is then stored in memory for future comparison using sub-
sequent breath samples. This becomes a voice print which can be
used in the future to determine various characteristics of a breath
sample.

Figure 4 shows Figure 1 expanded to illustrate the schematic
25 structure described with respect to Figure 1. To facilitate easy
correlation between Figures 4 and 1, the like structures of Figure 4
are numbered with the same numbers of Figure 1, and then aug-
mented with A-D. For example, the Figure 1 memory 36 will become
the Figure 4 separate memories 36A, 36B, 36C and 36D. This ar-
30 rangement is provided in order to permit the four characteristics
discussed regarding Table I to be coupled together and selectively
developed.

To accomplish this, a few additional items of apparatus need
to be added. To enable and disable the various sub-systems, a
35 switch control 128 is connected through a line 130 to control the in-
teractions among comparators 34A, 34B, 34C and 34D, as well as the
interaction with interlock 44.

Line 130 is connected through the plurality of junctions 132A,

1 132B, 132C and 132D to a plurality of respective switches 134A-D.
These in turn are each individually connected to each of three
respective enabling devices 136A, 136B and 136C. The purpose of
these enables is to successively test breath signature signal 32 ac-
5 cording to the hierarchy described in Items 1-4 on Table I.

For example, if signal 32 passes the comparison within com-
parator 34A, the output signal is positive. Since the signal passed,
it is routed through switch 134A to enable 136A, which in turn per-
mits comparator 34B to receive incoming breath signature signal
10 32B. Thus, moving from left to right, the Table I Items 104 can be
tested and sequenced, with each positive answer from the com-
parators causing the incoming signal 32 to successively undergo a
more rigid test.

Memory 36B is shown as having four different "reference
15 tables", one in each for the class of male, female, child and adult.
These in turn are coupled to deliver their signals along a bus out-
put signal 38B.

Figure 4 adds the concept that the breath signature signal 32
can be sent all the way through for storage in memory 78. Thus,
20 memory 78 would record each signal 32 resulting from each breath
test for future recall as desired.

In order for this Invention to work, it was necessary to iden-
tify and adapt a transducer capable of measuring the temperature,
pressure and humidity of a breath sample, and then some form of
25 apparatus for using these three pieces of information to produce the
unique breath signature signals required. Preferably, a transducer
was desired which could both measure these values as well as in-
tegrate together the measured values to produce the breath signa-
ture signal; such a transducer was found, identified by the
30 registered trademark KYNAR brand Piezo Film.

Kynar is a trademark of the Pennwalt Corporation. This
trademark is registered on the Principle Register maintained by the
U.S. Patent and Trademark Office. The address of the trademark
owner is: Pennwalt Corporation, KYNAR Piezo Film Group, 900
35 First Avenue, King of Prussia, PA, USA 19406.

This Kynar and Piezo Film (hereinafter "the film") is a
polyvinylidene fluoride (PVDF) exhibiting very high piezoelectric and
pyroelectric properties. It can be used to convert mechanical

1 deformation such as that induced by a pressure change of a breath sample, and convert a heat signal into an electrical signal, for example the heat contained in a breath sample. The film is produced as a thin sheet having metallized electrodes on both sides.

5 Electricity conducting leads can be attached to the metallized electrodes for conducting a signal developed by the transducer film away for processing. Additional information about this product can be obtained from the trademark owner, who also designs and fabricates the film.

10 According to this invention, the film is used as transducer 28 to (1) measure the temperature, pressure and humidity values in a breath sample, and then (2) integrate these values to produce a single output signal which is a unique breath signature signal for that particular breath sample. As previously described, this signature

15 signal can be compared as desired against various references to (1) establish the validity of the sample, (2) distinguish the sample from those of other samples, (3) select one particular sample from a group of samples, and (4) recognize that a sample came from a particular identifiable person.

20 In order to obtain a breath sample containing a drug such as alcohol, it is preferably to measure what is commonly referred to as a "deep lung breath sample". That is, when exhaling a breath sample into sampler 22, the person can exhale for a second or two seconds before deep lung air begins being exhaled. As its name

25 implies, deep lung breath comes from the interior remote portions of the lung, closer to the point of osmosis between the lung volume and the blood vessels interacting with the lung volume. For accurate measurement of a drug, a breath sample must come from deep within the lung.

30 A breath sample can be altered by having at least one of the temperature, pressure and the humidity altered. For example, the temperature of the gas coming from a compressed gas bottle would be below the range of temperatures commonly found in a human breath sample. This temperature variation means that the breath

35 signature signal 32 produced in response to the gas sample would result in a "not valid" result in the comparator 34. Likewise, the gas pressure delivered by a gas bottle would be in excess of the pressure delivered by a human breath sample.

1 TABLE I. DETERMINATIONS RE BREATH SAMPLES

	INFORMATION RE		INFORMATION
	<u>ITEM</u>	<u>BREATH SAMPLE QUESTION</u>	<u>OBTAINED</u>
5	1.	VALIDITY	Alter sample? (E.g., filter is desiccant)
			Yes-No (Is/Is Not Valid)
10	2.	DISTINGUISH	Person's sex & age?
			A. Male or Female & B. Child or Adult
	3.	SELECT	Same person?
			Yes-No (Is/Is Not Same Person)
15	4.	RECOGNIZE	Who gave the sample?
			Person's Identity (It's Mr. _____)

Comments:

20 A. Moving from Item 1 downward towards Item 4 results in an increase in cost, technical complexity, and quality of intelligence gathered.

B. This Table I is hereby incorporated by reference into the Patent Application to which it is attached.

25 The above example embodiments discussed in the Detailed Description illustrate only a few of the constructions and methods made possible according to this Invention. It is to be understood that the following numbered Claims provide the scope and definition of the Invention.

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WHAT IS CLAIMED IS:

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1. An apparatus for generating a breath signature signal for a person who delivers a breath sample to a breath sampler means, the apparatus comprising: a transducer means, communicated with the breath sampler means, for sensing at least the temperature, the pressure and the humidity of the breath sample, and in response generating a breath signature signal which distinguishes the person from a plurality of persons.

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2. The apparatus defined in claim 1, wherein the breath sample comprises: a deep lung breath sample.

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3. The apparatus defined in claim 1, wherein the breath signature signal comprises: a frequency spectrum generated by the integration of at least the temperature, the pressure and the humidity of the breath sample.

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4. The apparatus defined in claim 3, wherein: the integration is performed by the transducer.

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5. The apparatus defined in claim 1, further including a validifier means for determining that the breath sample is delivered unaltered to the breath sampler, the validifier means comprising: (a) a valid breath reference means for representing the valid common range of values of at least the temperature, the pressure and the humidity of the typical breath samples taken from a reference population of persons; and

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(b) a comparator means, coupled to the valid breath reference means and the transducer means, for comparing the breath signal against the valid breath reference means to determine if the breath sample is valid.

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6. The apparatus defined in claim 5, wherein the valid breath reference means comprises: a plurality of frequency spectrums produced by integrating at least the ranges of the values of the temperature, the pressure and the humidity of the breath samples from the reference population.

1 7. The apparatus defined in claim 5, wherein the valid breath
reference means comprises: a plurality of templates developed from a
plurality of frequency spectrums produced by integrating at least
the pluralities of the range of values of the temperatures, the pres-
5 sures and the humidities of the breath samples form the reference
population.

8. The apparatus defined in claim 5, further including a distin-
guisher means for distinguishing, with respect to the person, both
10 of (a) a male from a female, and (b) a child from an adult, the dis-
tinguisher means comprising:

(a) a separate class reference means for each of at least a group
of four separate classes comprising respectively a plurality of males,
females, children and adults, the class reference means containing
15 at least the ranges of the temperatures, the pressures and the
humidities of the typical breath samples characteristic of each of the
classes; and

(b) the distinguisher means being coupled to the comparator means
for comparing the class reference means with the breath sample of
20 the person to identify the person as being both (1) one of a male
and a female, and (2) one of a child and an adult.

9. The apparatus defined in claim 8, further including: a selec-
tor means for determining if a later breath sample was delivered by
25 the same person who delivered an earlier breath sample, the selector
means being communicated with the breath signature signal of both
the earlier breath sample and the later breath sample for comparing
the breath signatures to see if they are the same to thereby indi-
cate that the same person one of (a) did and (b) did not deliver
30 both breath samples.

10. The apparatus defined in claim 9, further including a recogni-
tion means for providing a positive identification of a person deliver-
ing a breath sample in the future, the recognition means
35 comprising:

(a) a personal identification reference means, created by record-
ing a specific breath signature signal produced by the transducer
means in response to a specific breath sample delivered in the

- 1 present by each of a group of specific persons who are to be identified in the future according to the specific breath sample to be given in the future by each of the specific persons; and
- 5 (b) the comparator means being communicated to the personal identification reference means and the transducer means, for comparing each of the specific breath signature samples to the values stored in the personal identification reference means, to confirm one of (1) the same person delivered both of the present and the future breath samples and (2) the same person did not deliver both of the
- 10 present and the future breath samples.

11. The apparatus defined in claim 1, further including: a sensing means, communicated to the breath sampler means, for detecting the presence of a drug in the breath sample.

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12. The apparatus defined in claim 11, wherein the drug comprises: an alcohol.

13. An apparatus for sensing the removal of at least a portion of a drug content of a breath sample delivered to a breath sampler means by a person, the apparatus comprising:
- 20 (a) a transducer means, communicated with the breath sampler means, for responding to at least the temperature, the pressure and the humidity of the breath sample, which may contain a drug, and
- 25 in response generating a breath signature signal;
- (b) a valid breath reference means, for representing the valid common range of values of the combination of at least the temperature, the pressure and the humidity of the typical breath samples not containing a drug and taken from a reference population of a
- 30 plurality of persons; and
- (c) a comparator means, coupled to the breath reference means and the transducer means, for comparing the breath signature signal against the valid breath reference means, to determine one of
- 35 (1) the breath sample is valid because the breath signature signal substantially matches the values in the reference means, and (2) the breath sample is invalid because the breath signature does not substantially match the values in the reference means.

- 1 14. The apparatus defined in claim 13, wherein the drug
comprises: an alcohol.
- 5 15. The apparatus defined in claim 13, wherein the invalid breath
sample comprises: a breath sample that has been altered by having
at least one of the temperature, the pressure and the humidity al-
tered.
- 10 16. The apparatus defined in claim 13, wherein the response by
the transducer means comprises: a breath signature signal in the
form of a frequency spectrum produced by the integration by the
transducer means of the values of the temperature, the pressure
and the humidity measured by the transducer means.
- 15 17. An apparatus for generating a breath signature of a person,
the apparatus comprising:
(a) a sampler means, for accepting a breath sample from the
person; and
(b) a transducer means, communicated with the sampler means, for
20 sensing at least the temperature, the pressure and the humidity of
the breath sample, and in response generating a breath signature
signal which is unique to the person.
- 25 18. The apparatus defined in claim 17, wherein the sampler means
comprises: a sealed chamber communicated to a mouthpiece.
19. The apparatus defined in claim 17, wherein the breath sample
comprises: a deep lung breath sample.
- 30 20. The apparatus defined in claim 17, wherein the breath signa-
ture signal comprises: a frequency spectrum generated by integra-
tion of at least the temperature, the pressure and the humidity.
- 35 21. The apparatus defined in claim 20, wherein: the integration
is performed by the transducer.
22. An apparatus for generating a breath signature of a person,
the apparatus comprising:

- 1 (a) a sampler means, for accepting a deep lung breath sample
from the person; and
(b) a transducer means, placed in fluid communication with the
sampler means, for measuring at least the temperature, the pressure
5 and the humidity of the breath sample, and in response generating
a breath signature signal being in the form of a frequency spectrum
produced by the integration by the transducer means of at least the
temperature, the pressure and the humidity of the breath sample.
- 10 23. A method for generating a breath signature of a person, the
method comprising the steps of:
(a) sampling the breath of the person; and
(b) transducing at least the temperature, the pressure and the
humidity of the breath sample into a breath signature signal unique
15 to the person.
24. The method defined in claim 23, wherein the sampling step
comprises: sampling a deep lung breath sample.
- 20 25. The method defined in claim 23, wherein the transducing step
comprises: integrating the temperature, the pressure and the
humidity to produce the breath signature signal.
- 25 26. The method defined in claim 25, wherein the integrating step
comprises: producing a breath signature signal in the form of a
frequency spectrum.
27. The method defined in claim 25, wherein the producing the
30 breath signature signal step comprises: employing a transducer to
perform the integrating step.
28. An apparatus for determining that a breath sample exhaled by
a person is delivered unaltered to a breath sampler, the apparatus
35 comprising:
(a) a human breath reference means, for representing the common
range of values of at least the temperature, the pressure and the
humidity of the typical breath samples taken from a reference

population of persons;

(b) a transducer means, communicated with the breath sampler, for sensing at least the temperature, the pressure and the humidity of the breath sample from the person, and in response generating a breath signal; and

(c) a comparator means, coupled to the human breath reference means and the transducer means, for comparing the breath signal against the human breath reference means to verify one of (1) the breath sample did come from a person, and (2) the breath sample did not come from a person.

29. The apparatus defined in claim 28, wherein the breath sampler comprises: an enclosed chamber having a mouthpiece for admitting the breath sample.

30. The apparatus defined in claim 28, wherein the breath reference means comprises: a plurality of frequency spectrums produced by integrating at least the range of the values of the temperature, the pressure and the humidity of the breath samples from the reference population.

31. The apparatus defined in claim 28, wherein the breath reference means comprises: a plurality of templates developed from a plurality of frequency spectrums produced by integrating at least the range of values of the temperature, the pressure and the humidity of the breath samples from the reference population.

32. The apparatus defined in claim 28, further including: a distinguisher means for distinguishing, with respect to the person, both of (a) a male from a female, and (b) a child from an adult, the distinguisher means having a separate class reference means for each of at least a group of four separate classes comprising respectively a plurality of males, females, children and adults, the class reference means containing at least the ranges of the temperatures, the pressures and the humidities of the typical breath samples characteristic of each of the classes, the distinguisher means being coupled to the comparator means for comparing the class reference means with the breath sample of the person, to identify the person

- 1 as being both (a) one of a male and a female, and (2) one of a
child and an adult.

33. A method for determining that a breath sample exhaled by a
5 person is delivered unaltered to a breath sampler, the method comprising the steps of:

- (a) representing, in a breath reference means, the common range
of values of at least the temperature, the pressure and the humidity
of the typical breath samples taken from a reference population of
10 persons;
- (b) measuring the values of at least the temperature, the pressure
and the humidity of the breath sample;
- (c) deriving a breath signal which is characteristic of the particular
values of the temperature, the pressure and the humidity of
15 the breath sample; and
- (d) comparing the breath sign to the breath reference means to
determine if the breath sample came directly from the person to the
breath sampler.

20 34. An apparatus for distinguishing both of (i) a male from a
female and (ii) a child from an adult, by measuring with a breath
sampler means a plurality of breath samples from a reference population
which includes each of a class of males, females, children and
adults, the apparatus comprising:

- 25 (a) a separate breath reference means for each of the classes,
containing at least the temperatures, the pressures and the
humidities of the typical breath samples characteristic of each of the
classes;
- (b) a transducer means, communicated with the breath sampler,
30 for sensing at least the temperature, the pressure and the humidity
of the breath sample taken from the particular person who is to be
identified as being (i) one of a male and a female, and (ii) one of a
child and an adult; and
- (c) a comparator means, coupled to the transducer means and to
35 each of the separate breath reference means, for comparing the
breath sample of the particular person to each of the separate
breath reference means, to identify the person as being (i) one of a
male and a female, and (ii) one of a child and an adult.

1 35. The apparatus defined in claim 34, further including: a
selector means for determining if a later breath sample was delivered
by the same person who delivered an earlier breath sample, the
selector means being communicated with the breath signature signals
5 of both the earlier breath sample and the later breath sample, for
comparing the signatures to see if they are the same to thereby in-
dicate that the same person one of (a) did and (b) did not deliver
both of the breath samples.

10 36. The apparatus defined in claim 35, further including: a
recognition means for providing a positive identification of the per-
son delivering the breath sample, the recognition means including a
personal identification reference means containing a breath signature
signal produced in the present by the transducer means for each of
15 the persons whose breath is to be sampled in the future, the recog-
nition means being coupled to the comparator means for the com-
parator means to compare each of the future breath samples to the
recognition means for positively identifying in the future the person
who provided the breath sample in the present.

20 37. A method using a breath sample for distinguishing both of (a)
a male from a female and (b) a child from an adult, the method
comprising the steps of:

25 (a) developing a reference means for each of the classes, derived
from at least the temperatures, the pressures and the humidities of
the typical breath samples characteristics of each of the classes;

(b) transducing at least the temperature, the pressure and the
humidity of the breath sample taken from the person who is to be
identified as being (1) one of a male and a female, and (2) one of a
30 child and an adult; and

(c) comparing the result of step (b) to the reference means of step
(a) to distinguish the person as being both (1) one of a male and a
female, and (2) one of a child and an adult.

35 38. The method defined in claim 37, further including the step of:
selecting to determine if a later breath sample is delivered by the
same person who delivered an earlier breath sample by comparing
the two breath signature signals to each other.

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- 1 39. The method defined in claim 38, further including the step of:
recognizing a particular person in the future, by comparing the
breath signature signal of the particular person in the future,
against a person identification reference means containing a breath
5 signature signal produced in the present by the transducer means
for each of the persons whose breath is to be sampled in the fu-
ture.

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AMENDED CLAIMS

[received by the International Bureau on 25 February 1987 (25.02.87);
original claims 1,3 17, 20 22, 23,25,26 and 30 amended; other claims unchanged (4 pages)]

1. (Once Amended) An apparatus for generating a breath signature signal for a person who delivers a breath sample to a breath
5 sampler means, the apparatus comprising: a transducer means, communicated with the breath sampler means, for sensing at least each of the temperature, the pressure and the humidity of a single breath sample, and in response generating a breath signature signal which distinguishes the person from a plurality of persons.
- 10 2. The apparatus defined in claim 1, wherein the breath sample comprises: a deep lung breath sample.
3. (Once Amended) The apparatus defined in claim 1, wherein
15 the breath signature signal comprises: a single frequency spectrum generated by the simultaneous integration of at least each of the temperature, the pressure and the humidity of the breath sample.
4. The apparatus defined in claim 3, wherein: the integration is
20 performed by the transducer.
5. The apparatus defined in claim 1, further including a
validifier means for determining that the breath sample is delivered
unaltered to the breath sampler, the validifier means comprising:
25 (a) a valid breath reference means for representing the valid common range of values of at least the temperature, the pressure and the humidity of the typical breath samples taken from a reference population of persons; and
(b) a comparator means, coupled to the valid breath reference
30 means and the transducer means, for comparing the breath signal against the valid breath reference means to determine if the breath sample is valid.
6. The apparatus defined in claim 5, wherein the valid breath
35 reference means comprises: a plurality of frequency spectrums produced by integrating at least the ranges of the values of the temperature, the pressure and the humidity of the breath samples

14. The apparatus defined in claim 13, wherein the drug comprises: an alcohol.

5 15. The apparatus defined in claim 13, wherein the invalid breath sample comprises: a breath sample that has been altered by having at least one of the temperature, the pressure and the humidity altered.

10 16. The apparatus defined in claim 13, wherein the response by the transducer means comprises: a breath signature signal in the form of a frequency spectrum produced by the integration by the transducer means of the values of the temperature, the pressure and the humidity measured by the transducer means.

15 17. (Once Amended) An apparatus for generating a single breath signature of a person, the apparatus comprising:

(a) a sampler means, for accepting a single breath sample from the person; and

20 (b) a transducer means, communicated with the sampler means, for sensing at least each of the temperature, the pressure and the humidity of the single breath sample, and in response generating a single integrated breath signature signal which is unique to the person.

25 18. The apparatus defined in claim 17, wherein the sampler means comprises: a sealed chamber communicated to a mouthpiece.

30 19. The apparatus defined in claim 17, wherein the breath sample comprises: a deep lung breath sample.

20. (Once Amended) The apparatus defined in claim 17, wherein the breath signature signal comprises: a frequency spectrum generated by the simultaneous integration of at least each of the temperature, the pressure and the humidity.

35 21. The apparatus defined in claim 20, wherein: the integration is performed by the transducer.

22. (Once Amended) An apparatus for generating a breath signature of a person, the apparatus comprising:

(a) a sampler means, for accepting a deep lung breath sample from the person; and

5 (b) a transducer means, placed in fluid communication with the sampler means, for simultaneously measuring at least each of the temperature, the pressure and the humidity of the breath sample, and in response generating a single integrated breath signature signal being in the form of a frequency spectrum produced by the
10 simultaneous integration by the transducer means of at least each of the temperature, the pressure and the humidity of the breath sample.

23. (Once Amended) A method for generating a breath signature
15 of a person, the method comprising the steps of:

(a) sampling the breath of the person; and

(b) transducing simultaneously at least each of the temperature, the pressure and the humidity of the breath sample into a single breath signature signal unique to the person.
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24. The method defined in claim 23, wherein the sampling step comprises: sampling a deep lung breath sample.

25. (Once Amended) The method defined in claim 23, wherein the
25 transducing step comprises: integrating each of the temperature, the pressure and the humidity to produce the single integrated breath signature signal.

26. (Once Amended) The method defined in claim 25, wherein the
30 integrating step comprises: producing a single breath signature signal in the form of a frequency spectrum developed from the simultaneous integration of each of the temperature, the pressure and the humidity.

35 27. The method defined in claim 25, wherein the producing the breath signature signal step comprises: employing a transducer to perform the integrating step.

28. An apparatus for determining that a breath sample exhaled by a person is delivered unaltered to a breath sampler, the apparatus comprising:

- 5 (a) a human breath reference means, for representing the common range of values of at least the temperature, the pressure and the humidity of the typical breath samples taken from a reference population of persons;
- (b) a transducer means, communicated with the breath sampler, for sensing at least the temperature, the pressure and the humidity
10 of the breath sample from the person, and in response generating a breath signal; and
- (c) a comparator means, coupled to the human breath reference means and the transducer means, for comparing the breath signal against the human breath reference means to verify one of (1) the
15 breath sample did come from a person, and (2) the breath sample did not come from a person.

29. The apparatus defined in claim 28, wherein the breath sampler comprises: an enclosed chamber having a mouthpiece for admitting
20 the breath sample.

30. (Once Amended) The apparatus defined in claim 28, wherein the breath reference means comprises: a plurality of frequency spectrums produced by integrating at least the range of the values
25 of the temperature, the pressure and the humidity of the breath samples from the reference population.

31. The apparatus defined in claim 28, wherein the breath reference means comprises: a plurality of templates developed from
30 a plurality of frequency spectrums produced by integrating at least the range of values of the temperature, the pressure and the humidity of the breath samples from the reference population.

32. The apparatus defined in claim 28, further including: a distinguisher means for distinguishing, with respect to the person,
35 both of (a) a male from a female, and (b) a child from an adult, the distinguisher means having a separate class reference means for

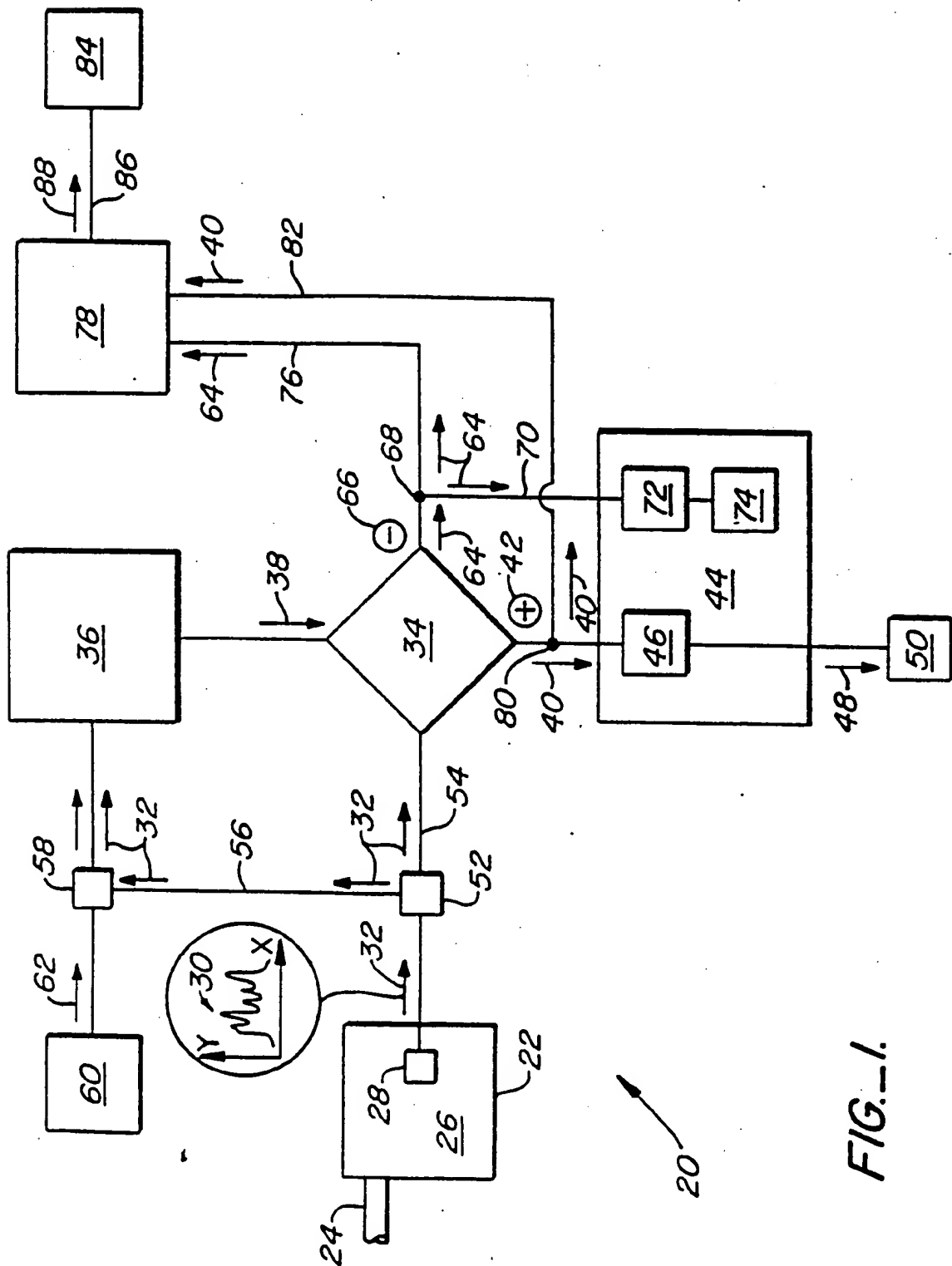


FIG. 1.

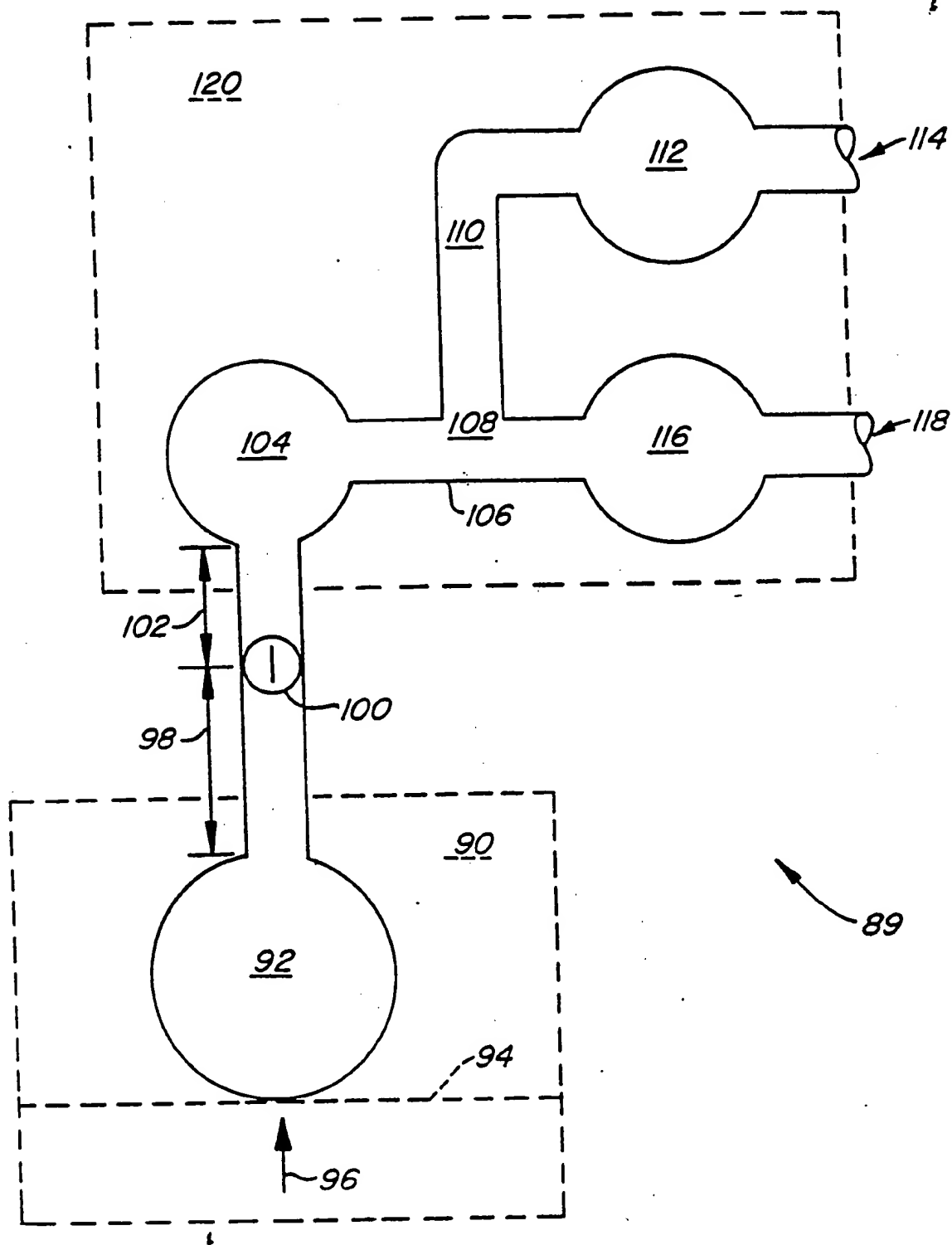


FIG. 2.

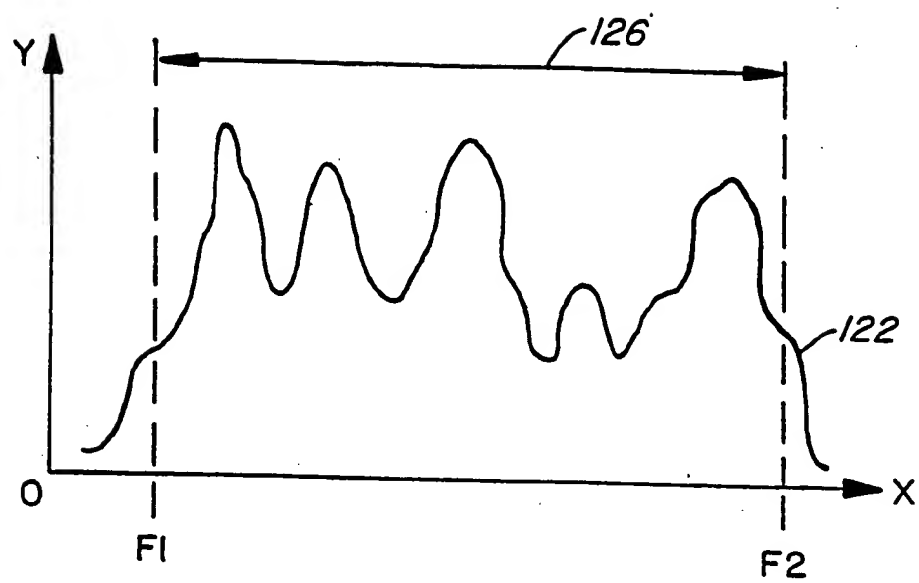


FIG. 3A.

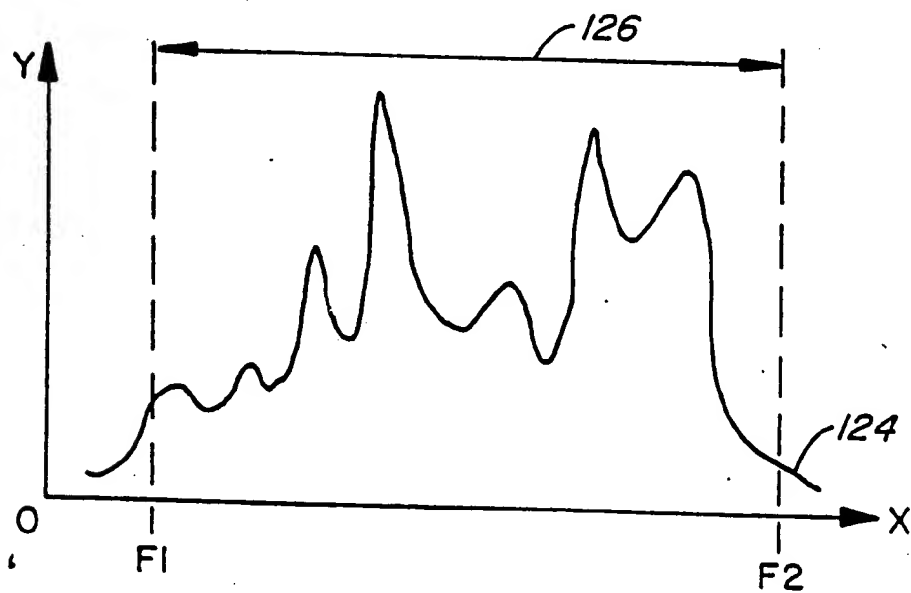


FIG. 3B.

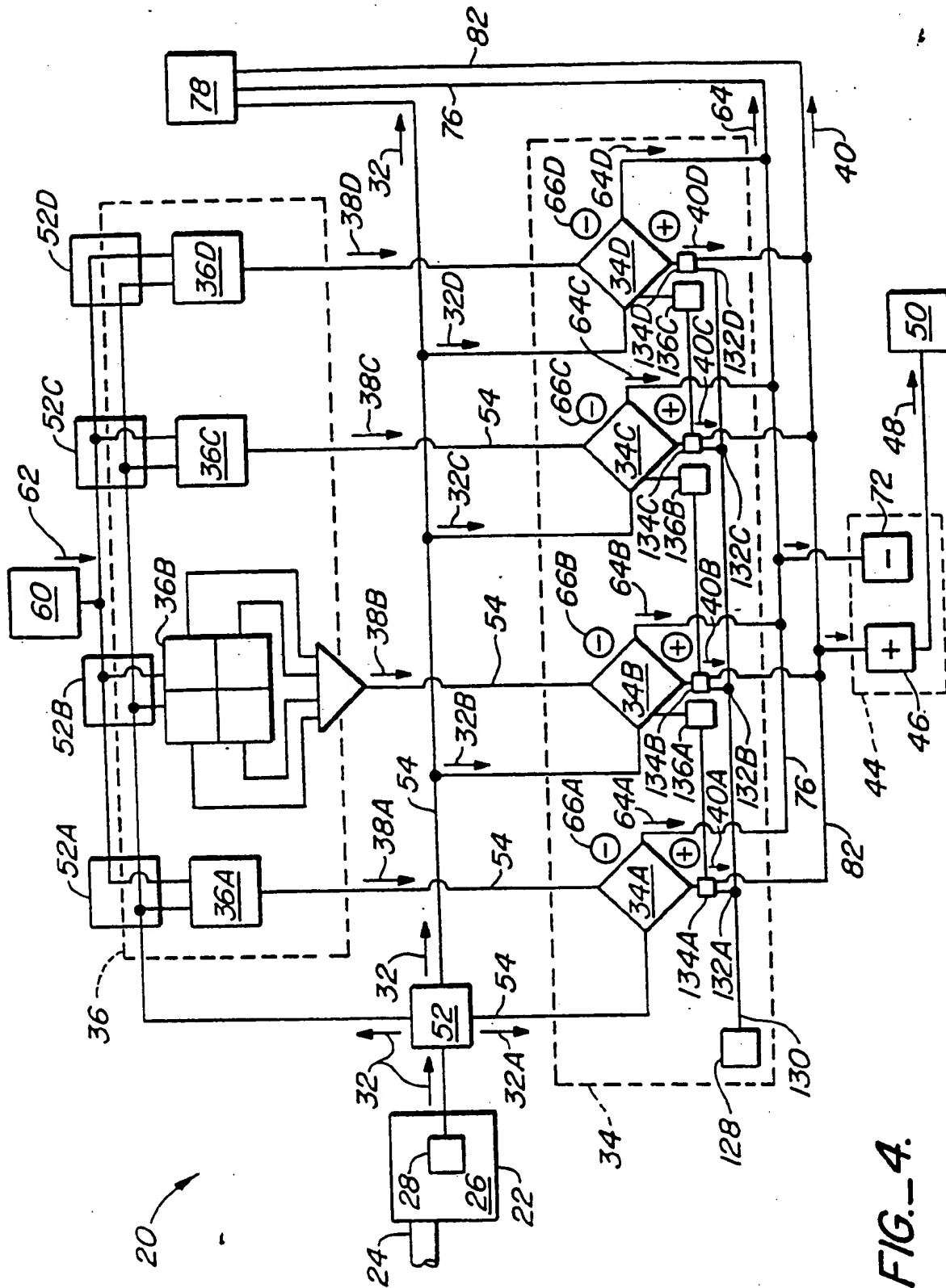
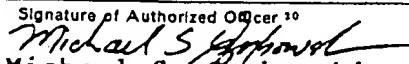


FIG. 4.

INTERNATIONAL SEARCH REPORT

International Application No **PCT/US86/02230**

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ³ According to International Patent Classification (IPC) or to both National Classification and IPC IPC (4): GOIN 33/00 U.S. Cl. 436/132		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁴		
Classification System	Classification Symbols	
U.S. 73/23,27R,593,659; 128/716,719,720,724 340/576; 422/84; 436/132		
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁵		
III. DOCUMENTS CONSIDERED TO BE RELEVANT ¹⁴		
Category ⁶	Citation of Document, ¹⁴ with indication, where appropriate, of the relevant passages ¹⁷	Relevant to Claim No. ¹⁸
Y,P	U.S., A, 4,608,995 (Linnarsson et al) 02 September 1986, See column 4 lines 17-32	1, 17, 22, 23
Y	U.S., A, 3,842,663 (Harting et al) 22 October 1974 See the entire document	3, 20, 26, 30
A	U.S., A, 4,399,684 (Advani et al) 23 August 1983	
A	U.S., A, 4,317,453 (Heim et al) 02 March 1982	
A	U.S., A, 4,316,380 (Heim et al) 23 February 1982	
A	U.S., A, 4,248,245 (Kempin) 03 February 1981	
A	U.S., A, 4,093,945 (Collier et al) 06 June 1978	
A	U.S., A, 3,831,707 (Takeuchi) 27 August 1974	
<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p>¹⁵ Special categories of cited documents:</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="width: 45%;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&" document member of the same patent family</p> </div> </div>		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search ²	Date of Mailing of this International Search Report ³	
04 December 1986	08 DEC 1986	
International Searching Authority ¹	Signature of Authorized Officer ¹⁹	
ISA/US	 Michael S. Gaybowski	